CONTINUING EDUCATION

Considerations for a Successful Clinical Decision Support System

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Clinical decision support systems have the potential to improve patient care in a multitude of ways. Clinical decision support systems can aid in the reduction of medical errors and reduction in adverse drug events, ensure comprehensive treatment of patient illnesses and conditions, encourage the adherence to guidelines, shorten patient length of stay, and decrease expenses over time. A clinical decision support system is one of the key components for reaching compliance for Meaningful Use. In this article, the advantages, potential drawbacks, and clinical decision support system adoption barriers are discussed, followed by an in-depth review of the characteristics that make a clinical decision support system successful. The legal and ethical issues that come with the implementation of a clinical decision support system within an organization and the future expectations of clinical decision support system are reviewed.

KEY WORDS

CDSS • Clinical decision support systems • HITECH Act • Meaningful use

MEANINGFUL USE AND CLINICAL DECISION SUPPORT SYSTEM

The Health Information Technology for Economic and Clinical Health (HITECH) Act, under the American Recovery and Reinvestment Act of 2009, was developed to encourage the usage and implementation of information technology within the healthcare system.[1] The goal of the HITECH Act is to achieve the Meaningful Use of electronic health record (EHR) systems throughout the nation.[2] The goals of Meaningful Use include using a certified EHR in a way that is considered meaningful, such as e-prescribing; the certified EHR in use is capable of sharing and receiving information; and the organization or physician must provide reports and results regarding quality of care and other related quality information to the Secretary of Health & Human Services.[2] The five main goals of Meaningful Use include "improving quality, safety, and efficiency and reducing health disparities"; "engage patients and families in their health"; "improve care coordination"; "improve population and public health"; and "ensure adequate privacy and security protection for personal health information."[2]

The HITECH Act allotted $22.6 billion to promote the implementation of information systems and clinical decision support systems (CDSSs) to be utilized within the healthcare setting.[1] The hospitals and physicians that achieve the requirements of Meaningful Use can receive payments of $44 000 over 5 years for Medicare providers or $63 750 over 6 years for Medicaid providers.[2] Organizations that do not participate in the incentive program by 2015 will initially have a 1% fee reduction that will increase to a 3% fee reduction by 2017 and later.[2] Healthcare settings that make the decision to implement the EHR must incorporate the use of a CDSS in order to qualify for the monetary incentive.[3]

According to Kleeberg et al,[4] the requirement for stage 1 Meaningful Use for a CDSS is to "implement one clinical decision support rule relevant to specialty or high clinical priority along with the ability to track compliance to that rule." To meet the requirements of stage 1 Meaningful Use, a CDSS must utilize individualized

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The authors have disclosed that they have no significant relationship with, or financial interest in, any commercial companies pertaining to this article.

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DOI: 10.1097/NXN.0b013e3182997a9c

patient information in order to suggest logical care alternatives to the user and must be able to generate variable suggestions or variable information based on the unique individualized patient information.[4]

The CDSS requirement for stage 2 Meaningful Use for 2014 is to "improve performance on high-priority health conditions."[5] Five CDSS interventions that correlate with four or more clinical quality measures must be implemented. It is also required that drug-drug and drug-allergy interaction verifications are implemented in order to meet the stage 2 Meaningful Use objectives.[5]

CLINICAL DECISION SUPPORT SYSTEM OVERVIEW

Many important matters have to be considered when planning the care of a patient. The patient's vital signs, medications, allergies, medical history, diagnoses, treatments, and so on need to all be taken into account. The safety risks increase when caring for multiple patients. Many errors can potentially occur if the patient load is high, patient histories are incomplete, allergies are forgotten, treatments are neglected, or guidelines are not followed. A CDSS aim to better the safety and quality of patient care, improve patient care treatments and outcomes, decrease the dependence on memory, lower error rates, and decrease response time.[6] A CDSS is a type of software that interprets specific patient information that is entered into the system in order to provide assistance in making the most appropriate and safe decisions when providing patient care.[7] Clinical decision support systems support users with the detection and prevention of possible risks to patient safety and encouraging the appropriate usage of evidence-based practice and guidelines.[4]

Clinical decision support systems assist in making the best decision regarding patient care by gathering all pertinent data and information needed so that it is easily accessible to the user in one place.[8] A CDSS takes the data and information entered and processes this information with the utilization of organizational models, algorithms, and calculations in order to achieve a variety of potential action options based on the unique circumstances of the individual patient.[8] The information that is gathered by a CDSS about a specific patient is presented with prompts, alerts, or recommendations to the correct user at the most appropriate time.[4,9,10]

CLINICAL DECISION SUPPORT SYSTEM TYPES

A CDSS can be a general program that is used as developed by the vendor with no alterations, a system developed by the vendor that has customized components, or a system that is custom-built for an organization.[6] Clinical decision support systems can either be active or passive. An active CDSS presents information to the clinician that is retrieved by comparing available patient information with the programmed rules, protocols, and guidelines by utilizing a knowledge base, available patient information, and an inference engine.[6] A knowledge database includes organizational protocols, guidelines, and rules developed using evidence-based research.[6] Available patient information includes data retrieved from physiological monitors, test results, and data entered by clinicians.[6] The inference engine compares the available patient information with the knowledge base in order to deliver pertinent information to the user.[6] Active CDSSs deliver information with the immediate presentation of alerts and suggestions regarding medication interaction or dosages, allergies, critical laboratory values, and other reminders regarding patient care.[6] A passive CDSS presents additional available resources for the clinician to access through a link if further information is desired.[6]

CLINICAL DECISION SUPPORT SYSTEM PROCESS

A CDSS utilizes a knowledge base and inference engine to carry out appropriate suggestions, alerts, or reminders. The user enters patient information, such as vital signs, allergies, important medical history, medications, or laboratory test results into the system or another interfacing system.[7] The inference engine then takes this information and compares it with the information available in the knowledge database.[7] An alert will generate if the information entered meets the criteria of the rules programmed in the knowledge database.[7] For example, if the user enters a febrile oral temperature reading, a prompt for a blood culture order will be generated if no blood culture had been drawn in the last 24 hours.

CLINICAL DECISION SUPPORT SYSTEM ADVANTAGES

Clinical decision support systems have the potential to improve patient care in a multitude of ways. A CDSS can aid in the reduction of medical errors and reduction in adverse drug events, ensure comprehensive treatment for patient illnesses and conditions, encourage the adherence to guidelines, and shorten patient length of stay. A successful CDSS that can effectively operate and achieve the previously stated outcomes may potentially decrease the expenses of an organization. Multiple studies on CDSS have confirmed that its use with medication administration

and health prevention decision support results in improved quality of patient care delivery.[10] Clinical decision support systems provide enhanced communication across multiple disciplines, improved accessibility to references on best practice, improved adherence to care guidelines, and a more consistent quality of patient care resulting in better patient outcomes.[11] A CDSS alerts and reminders support and encourage continuous learning for nurses at the novice level and reinforce already known knowledge in nurses who are experts.[8,12] The prompt delivery of care options to the users aids in expediting the decision-making process regarding patient care.[8,14]

CLINICAL DECISION SUPPORT SYSTEM POTENTIAL DRAWBACKS

Although a CDSS has many potential benefits, a CDSS is not infallible. Although the purpose of a CDSS is to improve patient care quality and safety, it has the potential to be more harmful than good.[15] A CDSS can be more harmful if the system does not function optimally; the users are not trained adequately to use the system; the information being presented by the CDSS is inappropriate; or the CDSS is not incorporated well into the current workflows.[15] A user interface that is too busy or difficult to navigate can lead to user frustration. Multiple alerts or pop-ups can become a nuisance to the user, leading to alert fatigue. The CDSS issues aforementioned can significantly slow down the workflow, efficiency, quality, and safety in the delivery of patient care.

Distrust

Users of a CDSS can experience mistrust in the system because knowledge that is portrayed by a CDSS regarding gathered patient information may not be uniform across multiple institutions because there is no formalized knowledge that is nationally being utilized.[16] "The formalization of knowledge involves translating clinical descriptions of patients and observations into standardized formats."[16(p22)] The formalization of knowledge in CDSSs has been hindered by the lack of agreement on a standardized language; therefore, the knowledge that is generated by one CDSS may not be identically duplicated by another CDSS in another organization.[16]

Clinical decision support systems are not capable of mimicking decision making at the level of the human mind. Instead, assumptions are made by following rules that are programmed by humans; thus, if programmed rules are outdated, the decision support that is generated will be outdated.[16] A CDSS cannot independently keep up with the constantly evolving healthcare knowledge and must be manually updated continuously and regularly to reflect the infinite changes in healthcare.[16]

Clinical decision support systems can also be prone to generating erroneous alerts. A CDSS that generates inappropriate or erroneous prompts, alerts, or suggestions can affect how users view the system. Erroneous alerts may occur if important information regarding a patient is omitted and is not included for consideration when processing the available information needed to generate options for decisions in care.[8] The generation of erratic decision support alerts can also occur if a CDSS has incorrectly programmed rules. Unsuitable suggestions regarding patient treatments that are generated from patient information that is incompletely entered by users or caused by simple faulty programming can lead to the incorrect delivery of care.[17] Errors in processing can lead to a decreased use of the system caused by the uncertainty of the safety and accuracy of the CDSS.[8,18] Users will lose confidence in the CDSS if errors in information or guidelines are frequently found.

The system's design can heavily affect how users trust the decision support tool. A CDSS that is not tailored to the unique clinical workflow of a specialized area may cause a decrease in work efficiency and discourage the usage of the system.[8,18] Clinical decision support system rules that do not fit within the area that the system is being applied can impair its main purpose of efficiently facilitating safe decision making.[17] Alert fatigue occurs when users experience desensitization to alerts and no longer acknowledge them, which ultimately defeats the purpose of promoting the safety, efficiency, and quality of patient care.[19] A CDSS that is not programmed so that it has sufficient knowledge and information regarding unique areas of patient care will cause users to feel that they are unable to depend on the tool to aid in decision making.[16] A decreased trust in the automation of a CDSS can cause users to dismiss the tool and disregard suggestions. Users may feel that they can complete tasks and patient care faster by disregarding the use of the CDSS. According to previous studies, 49% to 96% of prompts are overridden or ignored by users.[19,20] Distrust of the users can eventually lead to the deactivation of the CDSS in hopes to remove the unreliable alerts in order to improve workflow.[16]

Clinical Decision Support System Overdependence

Users may become too dependent on the alerts and reminders generated by the CDSS that they neglect to use their own critical-thinking skills and good clinical judgment.[8,13,14,16,20] Overdependence can pose serious risks and potential harm to patients. Users may not feel the need to double check dosages because they expect that the

CDSS will catch all discrepancies and errors. Clinical decision support systems are designed to support decision making rather than making the decisions for the user. The user should be the one to make the final decision based on his/her knowledge, experience, and practice guidelines. The capability of a CDSS to interpret information should not be substituted for human critical thinking. The interpretations are presented to provoke the act of critical thinking from the user in order to come to an educated and logical conclusion.

BARRIERS TO CLINICAL DECISION SUPPORT SYSTEM ADOPTION

The cost of CDSSs, workflow incorporation, lack of existing information systems, and lack of staff available for training and education on the system are major barriers that can make it difficult for an organization to adopt a CDSS. The development, implementation, and maintenance of a CDSS are extremely costly, and some hospitals may not be able to afford the system.[21] Difficulty in successfully incorporating a CDSS without interrupting the workflow can impede the adoption of a CDSS.[4,8,10,21] It is important to find the most suitable system that fits the existing workflow of the organization so that the implementation will lead to a higher likelihood of success. A large number of hospitals do not have an existing computerized physician order entry or EHRs, which makes it difficult to implement CDSSs without having those major systems in place.[21] In addition to a complete lack of or inadequacy of interfacing systems, some organizations may not have the adequate organizational support or the hours required to adequately educate and train users on the new system.[11]

SUCCESSFUL CLINICAL DECISION SUPPORT SYSTEM CHARACTERISTICS

Incorporation of Clinical Decision Support System Into Existing Systems

Many successful CDSSs are those incorporated into existing EHRs and computerized physician order entry systems and have the advantage of using the available data within those systems to effectively generate prompts.[21] An organization should ensure that the CDSS can be integrated smoothly into the existing systems before deciding on a CDSS product.[22] It should be confirmed that the chosen CDSS is compatible with the systems that are already in place to prevent any unwanted failures and difficulties in implementation.

Clinical Decision Support System Integration Into Current Workflow

Users are more willing to utilize a CDSS if the system does not disrupt their usual workflow, and the prompts are presented when the user is in the process of making the decision.[4,8,10,21,23] Any CDSS that requires a user to be away from patient care for too long is extremely undesirable, and users will not want to support its implementation.[24] Clinical decision support systems are meant to make patient care more efficient, and if a CDSS is occupying copious amounts of time that could be used for patient care, then it is not benefiting the user or the patient.

Clinical Decision Support System Specificity

Clinical decision support systems that are customized to a specific specialty area and provide broad spectra of various interventions are more inclined to be utilized properly.[21] Rules that are not specific enough and more generalized can result in the generation of excessive alerts causing the user to become desensitized.[25] Desensitized users resort to overriding or canceling alerts.[25] However, CDSSs that have rules that are too specific will not appropriately generate the proper alerts for criteria that need attention.[25] Clinical decision support systems increase in usefulness as the sensitivity and specificity of the prompts and suggestions presented are increased to an acceptable extent.[10,25,26] Having rules that are tailored and relevant to a unique area is beneficial in that all alerts, prompts, suggestions, and so on will be appropriate for the setting. Users will not be disrupted with alerts or information that does not relate to their area of expertise, thus decreasing the occurrence of possible alert fatigue. For example, if a physician logs into the system, only alerts regarding the physician's responsibilities should generate, and if a nurse logs into the system, only alerts pertaining to his/her field of responsibility should generate. The physician should not receive alerts regarding nursing responsibilities, and the nurse should not receive alerts regarding physician responsibilities. The CDSS can be tailored to specialty fields. For example, a renal unit may have many renal failure patients with chronic baseline high blood urea nitrogen and creatinine numbers. For a normal healthy patient, an alert would generate for the abnormal values. However, if this alert occurred on the renal unit, multiple inappropriate alerts would occur because the population's baseline levels are higher. The multiple alerts regarding high values for blood urea nitrogen and creatinine would become a nuisance to the nurses and physicians because the high values are to be expected within this population.

The CDSS should provide alerts that are applicable to the user's responsibilities and relevant to the patient population in order for the user to accept the provided support and clinical suggestions as suitable and trustworthy.

Clinical Decision Support System User Involvement

User involvement in the planning, development, design, and implementation of the CDSS is beneficial to the final acceptance and efficient utilization of the CDSS.[8,22,27–29] Increased involvement gives the users a sense of ownership of the CDSS.[22] Users will feel a higher responsibility toward the CDSS and have a more accepting attitude and willingness to work with the implementation of the system. The chance of a successful implementation will be high as long as the end users maintain good communication with the designers of the CDSS.[24] Communication between the users and the developers of the system is imperative in order to achieve optimal CDSS outcomes for the specified area.

Clinical Decision Support System Education and Training

Users who are thoroughly trained in the use of a CDSS are more likely to effectively use the system.[12] Having a thorough understanding of how the CDSS works and operates increases the user's ownership of the system, which may encourage the user to feel more engaged in the use of the CDSS as well as be more accepting.[12] In contrast, users who are not adequately educated on the use of the CDSS are more likely to show resistance and disapprove the CDSS being implemented.[12] Users must receive sufficient teaching regarding the CDSS in order to have a clear knowledge and understanding of the system. Studies have shown a positive correlation between increased knowledge and understanding of CDSSs with increased acceptance of the adoption of CDSSs, and those with inadequate knowledge had negative feelings toward CDSSs.[8,16,18,22] Users with adequate knowledge and education showed increased efficiency and competency when working with a CDSS.[22,24] Individual computer skills also affect whether the CDSS is used correctly.[30] Users should have the opportunity to take additional classes to improve their computer skills so that they have a more pleasurable and rewarding experience with the CDSS. Users are more willing to welcome a CDSS system as long as they know that the purpose of the system is to improve their efficiency and safety in patient care.[24] Users must be thoroughly introduced and trained with the CDSS in order to fully experience the benefits of decision support.

Sufficient Clinical Decision Support System Support

The presence of administrative assistance and designated CDSS unit experts is vital so that they are readily available to help users utilize the CDSS correctly and effectively.[24] Training individuals who work on the units to be super users guarantee that there will always be support for the end users by someone who understands the area that they work in and understands how to operate the CDSS. Having consistent support available from fellow employees can increase the acceptance of the system, thus increasing its effectiveness in improving quality and safety of patient care. In addition to the super users on the floor, 24/7 on-call information technology support availability is desired if the super-users are not able to resolve an issue with the CDSS. The presence and availability of sufficient support during initial implementation as well as after implementation are vital in decreasing anxiety and frustration. Easily accessible support staff can foster a more positive attitude toward the use of a CDSS.

Automated Clinical Decision Support System Prompts

The generation of automatic prompts with suggestions provided to the user increases CDSS efficiency.[10,23,31] Providing users with automated alerts with suggestions and resources available within the alert decreases time that would have been occupied having to navigate to other resources; thus, the workflow is not interrupted, and decisions can be made more quickly. The presence of automatic prompts prevents the user from having to interrupt their workflow by looking elsewhere for information. The automatic prompts should also be generated and presented to the user during the task at hand within the user's workflow.[4,8,10,21,23,26]

Straightforward Alerts

Clinical decision support system alerts that are developed should be unambiguous and easy to understand so that the user is clear on the circumstances at hand and understands what actions are needed.[4] Clinical decision support systems should be integrated into the workflow so that the alerts or suggestions are associated with the user's current task.[4,8,10,21,23] Clinical decision support systems should generate alerts early so that the user does not waste time and is not burdened by undoing actions that could have been corrected if the alert had occurred earlier in the process.[4,9] Alerts that are generated should contain brief, simple statements that are focused and to-the-point.

Studies have shown that users are more open and willing to utilize a CDSS when they are familiar with the rationale behind the guidelines and suggestions.[26] Clinical decision support systems should process quickly, and the user's workflow should be only minimally delayed. User approval decreases if a CDSS takes too long to process and causes inconvenient interruptions to workflow.[9]

Simple Clinical Decision Support System Displays

Basic guideline information should be presented as simply as possible on a single screen window so that users can get important relevant information quickly and easily.[9] The user interface should be simple, easy to navigate, and uncluttered. Simple displays allow the user to quickly read what needs to be read with no additional, unnecessary information and allow the user to work quickly and efficiently without compromising workflow.

Clinical Decision Support System Prompt Acknowledgement

Prompts should be made so that users must acknowledge them before continuing.[9] Instead of forcing a user to dismiss an order altogether, users should be offered the opportunity to choose alternative appropriate choices.[9] Having suggestions and prompts that must be acknowledged in order to move on is effective in changing user behavior and forcing the user to verify whether selections regarding patient care were appropriate.[9] Users may resist being limited to ordering only the treatments suggested by the CDSS that may not be the most beneficial for the patient.[21] The CDSS tool should allow the user to enter an explanation as to why he/she chose not to follow the suggestion.[20]

Minimal Clinical Decision Support System Data Entry

Additional traits of a CDSS that improve efficacy include allowing a minimal amount of user-entered data.[10,26] User resistance may occur if the CDSS cannot be integrated with current systems and cannot pull existing data from the existing systems.[24] Users will be inconvenienced by being required to enter redundant data that could not be captured. Users feel that it is inconvenient and troublesome if they are required to enter copious amounts of data when using a CDSS.[10] Studies have shown that the inconvenience of being required to enter large amounts of data causes users to feel unhappy with the system.[10]

Clinical Decision Support System Evaluation and Monitoring

The override rate of newly implemented CDSS rules should be evaluated as well as whether the targeted quality measure shows improvement.[4] In addition to evaluating override rates, the frequency of generated alerts should be evaluated and monitored continuously. Any alerts that occur repeatedly can be reviewed to see whether the criteria for the alert can be revised so that it does not occur as frequently.[9] Regular feedback from users should be obtained and analyzed so that any issues that have the potential to frustrate users can be resolved as soon as possible. Quickly resolving issues may limit users from developing feelings of resistance and negativity toward the CDSS.

CLINICAL DECISION SUPPORT SYSTEM LEGAL ISSUES

Clinical decision support system vendors are required to divulge all of the strengths and limitations of the software that they are providing to the users.[17] No information should be hidden from the user, and any limitations that may become a potential issue during and after implementation should be shared. Users should also be informed of the sources that were utilized to build the knowledge base of the CDSS software.[17] The knowledge base needs to be accurate and up to date with continuously changing practice. All additions that were incorporated into the system should be provided, and the user should be aware of additional costs of any specific needs that are desired.[17] The CDSS software provider should discuss the amount of education and training that their staff will need to plan for in order to use the CDSS tool safely and efficiently.[17] As stated before, education and training are very important components that are needed for a successful CDSS. The vendor must communicate with the users about who will have access to the system and who will have the power to accept, deny, or take action regarding the CDSS patient care.[17]

CLINICAL DECISION SUPPORT SYSTEM ETHICAL ISSUES

Ethical issues are of concern with CDSSs due to the fact that there is a risk of patient harm if the tool is not developed or used correctly. The Software Engineer Code of Ethics and Professional Practice guarantees that the system being developed is beneficial to the user and causes no harm.[16] All persons involved in the development of

CDSS software and implementation of the system are accountable for any outcomes that result from the use of the system developed, whether it is good or harmful to the patient.[16] Great care should be taken when developing CDSSs because any errors that are not caught prior to implementation can become a detrimental error that reaches a patient.

Ethical concerns related to CDSSs include standards of care, proper utilization, suitable users, and effect on relationships between professionals.[16] An ethical concern related to the standards of care is the decision about when to change the decision support tool from an experimental tool to one that will be actively used in an organization.[16] Multiple errors or problems with the system may occur after the transition from an experimental program to active use in its early stages of implementation.[16] It is extremely important for users to be vigilant and not to overly rely on the CDSS, but to make sure they use their own common sense and critical-thinking skills during the early stages of implementation. Users are expected to be competent in their fields and be capable of making logical and safe decisions that prioritize patient safety.

To further protect the safety of the patient population, it is ethically expected that the CDSS being developed is fashioned toward all members of the team who will be using it instead of having one specialty heavily influencing the design.[16] The CDSS should encourage the users of multiple disciplines to utilize the system and feel that it was designed with each specialty in mind. Users may feel comfortable with the use and design of the tool when the objectives and concerns of all involved disciplines are integrated into the system, which leads to the safe delivery of quality patient care. The users should be well prepared and trained on the CDSS so that the user takes the appropriate actions to preserve patient safety when prompted by alerts.[16]

A concern for a decrease in professional relationship is caused by overdependence on CDSSs.[16] Users may not feel the need to consult colleagues regarding their plans for patient care if uncertain, but totally rely on the CDSS instead. The lack of interaction and communication can lead to missing information that cannot be retrieved from the available information system that may be vital in providing the safest care possible to the patient.[16,20] Users may alter their plan of care in order to avoid or prevent alerts from occurring, even though it may not be the best decision for the patient's plan of care.[16] Instead of discussing alternative plans with their peers, the patient receives subpar treatments or treatments that are unnecessary just to fit the criteria of the CDSS. Previously learned knowledge in the clinical setting may become dulled because of the CDSS providing most of the information automatically to the user, lessening the user's need for further independent learning. The resulting quality of care that the patient receives becomes an ethical concern.

CONCLUSION

A CDSS is an integral piece of meeting the Meaningful Use criteria in order to better the quality and safety of patient care. Many aspects have to be considered when implementing a CDSS. Without proper preparation and planning, a CDSS implementation can fail very quickly. It is important to keep in mind that in order to have a successful CDSS, the system must be incorporated into the existing workflow and existing health information systems; involve end-users during all stages of the implementation; provide sufficient training, education, and support; keep alerts simple, straightforward, and specialized to the area of use; and require users' acknowledgement of prompts, alerts, or suggestions. With these suggestions, the CDSS will have a higher chance of success.

FUTURE EXPECTATIONS

Clinical decision support systems will continue to advance in the future as its use continues to spread. As more hospitals and physicians incorporate CDSSs into their practice, it is expected to eventually develop formalized knowledge so that the CDSS language can be uniform and have clear meaning throughout multiple health institutions. In addition to developing formalized knowledge, it would be beneficial to have a database available for all CDSSs to automatically and regularly pull updated health information and best evidence-based practice guidelines and rules to support the safe delivery of patient care instead of having to manually update the CDSS regularly. Having a single database used to update all CDSSs could ensure consistent and uniform care throughout the entire healthcare system. The ability of a CDSS to retrieve automatic updates on the continuously changing science of healthcare has the potential to further increase the trust in the system's accuracy, leading to greater acceptance of system use.

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